Saskatchewan

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Agriculture Development Fund

FINAL REPORT

USING DOCKAGE PRE-CLEANERS TO ADD VALUE TO GRAINS

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July 2000

Prepared by: PAMI

SAF
Saskatchewan Agriculture & Food

Adding value to agriculture...through research and development

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Project No. 7099E
Date: July 2000
Humboldt, Saskatchewan

ADF #98000269

Research Report

Final Report

Using Dockage Precleaners to Add Value to Grains

for:
Agriculture Development Fund
Regina, SK

PAMI
Prairie Agricultural Machinery Institute

Project No. 7099E
Date: July 2000
Tested at Humboldt

ADF#98000269

Final Report

Using Dockage Precleaners to Add Value to Grains

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1. Summary

Three grain precleaners were tested in wheat, canola, and peas. The grain flowrates and cleaning effectiveness were determined at different operating conditions. In some cases, there was an optimum setting for maximum flowrate and cleaning effectiveness, but in many cases, adjustment had no effect on the precleaners' performance.

Based on the test results, an economic analysis of a typical grain precleaner was done. When used to remove dockage in an attempt to reduce freight costs, there is a net economic disadvantage to using a precleaner. However, if the precleaner can be used to improve the grade of the grain, there is a large positive economic benefit to using these machines.

2. Technical Report

2.1 Introduction

For several years, precleaners have been available on the prairies. These machines are simple grain cleaners that are meant to remove a portion of the dockage or do some simple grain size selection. Because freight has become a significant cost to Saskatchewan producers there has been more interest in reducing freight costs by not shipping the dockage. Using these precleaners to remove the dockage or add value in other ways is a potential method to keep more of the total grain revenue in Saskatchewan. This project was done to evaluate the performance of available precleaners and to use this information to assess the economics of using precleaners to add value to Saskatchewan crops.

2.2 Objectives

The objectives of this project were:

1) Obtain and test precleaners that are available in Saskatchewan.
2) Assess the economics of using precleaners at the conditions used during testing.
3) Assess the economics of using precleaners for several other operating conditions.

2.3 General Description

Three precleaners were tested in this project. They included the Farm King 480, manufactured by Farm King; the Kwik Kleen Model 772, manufactured by Triangle Industries; and the Mobile Screen, manufactured by Bench Industries.

The Farm King precleaner uses two cylindrical rotating screens to remove both large and small particles from the grain (**Figure 1**). The input grain is conveyed into one end of the inner screen using an auger supplied with the precleaner. The large particles stay on the interior of the inner screen and move toward the rear of the machine and over a chute on the rear of the precleaner. The desired grain and small particles fall through the inner screen onto the outer screen. The desired grain stays on the interior of the outer screen and moves toward the rear of the machine and over a chute at the rear of the precleaner. The small particles fall through the outer screen and drop into an auger, which discharges the small particles at the front of the machine. Three additional conveyors are needed to move the small particles, large particles and desired grain from the precleaner.

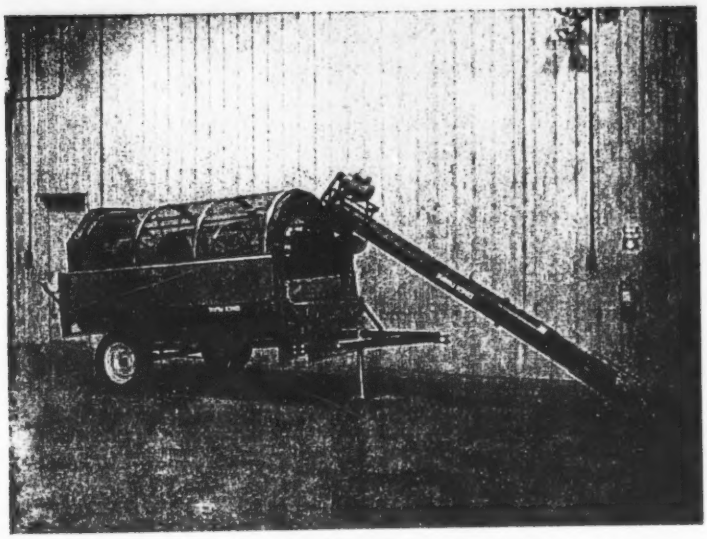

Figure 1. Farm King 480 Precleaner.

Both inner and outer screens can be changed for different grains or cleaning operations. The angle of the machine can be changed to vary the residence time in the precleaner, thereby changing the grain flowrate and cleaning efficiency.

The Kwik Kleen precleaner has seven augers in cylindrical screens to remove small particles from the grain (**Figure 2**). The input grain is dumped into a receiving hopper from a truck and the flow into the bottom of the augers is regulated using an adjustable slide gate. As the grain moves up the seven augers, the small particles fall through the screens. The desired grain continues through the augers and is discharges at the end of the precleaner opposite the receiving hopper. Paddles in the auger flighting mix the grain as it travels along the auger. The small particles drop into a bed of three augers that move the material to a discharge auger that discharges the material into a truck or other container. One conveyor is needed to move the desired grain from the precleaner.

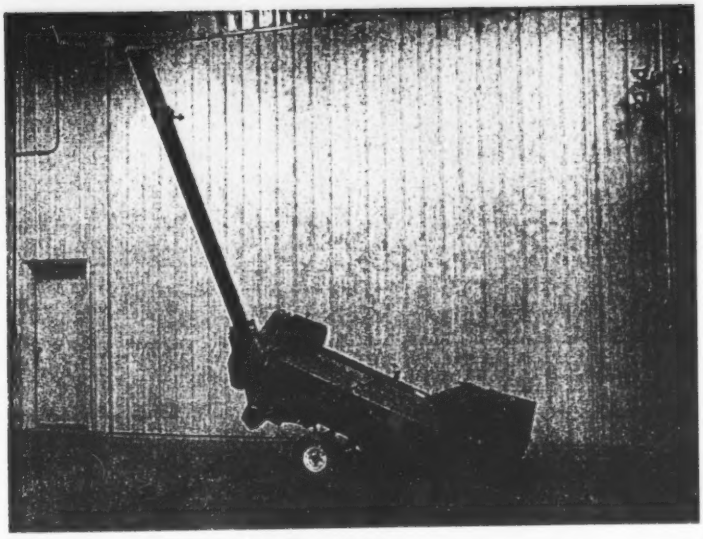

Figure 2. Kwik Kleen 772 Precleaner.

All screens can be changed to remove different sizes of particles from the input grain. The angle of the machine and auger speed can be changed to vary the grain flowrate and cleaning efficiency.

The Mobile Screen precleaner has two oscillating screens to remove both large and small particles from the grain (**Figure 3**). The input grain is conveyed to the front end of the screen using an auger supplied with the precleaner. The grain passes through a distributor and then onto the top screen. The large particles stay on top of this screen until they fall off the rear end of the screen, where they pass over a chute that directs them to one side of the rear of the precleaner. The desired grain and small particles fall through the top screen and on to the bottom screen. Rubber balls between the screens help to dislodge any particles stuck in the top screen. The desired grain stays on top of the bottom screen and when it gets to the rear of the screen, it is funnelled into a stream that falls off the rear of the precleaner. The small particles fall through the bottom screen on to a shaker pan that moves them to the rear of the machine, where they are directed to the same chute as the large particles. Two additional conveyors are needed to move the desired grain and removed particles from the precleaner.

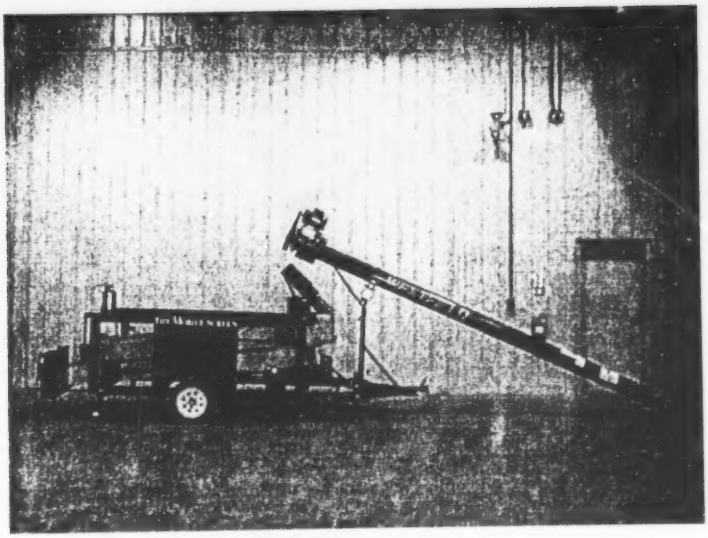

Figure 3. Mobile Screen Precleaner.

Both screens can be changed for different grains or cleaning operation. The precleaner could also be configured so the input grain travelled over both top and bottom screens simultaneously if it was desirable to only remove the small or large particles. The machine angle, oscillating stroke, and oscillating speed, could be changed to vary the grain flowrate and cleaning efficiency.

2.4 Scope of Test

2.4.1 Performance Tests

All three precleaners were operated at PAMI in Humboldt while cleaning wheat, canola and peas. Grain was obtained from a local elevator, and all grain contained a typical amount and composition of dockage. Each precleaner was operated at maximum grain flowrate and a lower flowrate (about half of maximum) at different machine settings. During each test run, the desired grain was conveyed into a truck equipped with a weigh scale. The other output streams were combined and conveyed into a container suspended from a load cell. By weighing all material leaving the precleaners, flowrates could be determined. During each test run, samples of the input grain, desired grain and removed grain were collected. The composition of all wheat samples was determined by passing them through a Carter Dockage Tester and weighing all portions. The composition of all pea and canola samples was determined by using hand screens and weighing all portions. The screen sizes used in all tests were those suggested by the Canadian Grain Commission.

2.5 Test Results

All of the test results for all precleaners were entered into an Excel spreadsheet for data analysis. Complete test data is given in **Appendix I**. To make comparisons easier, two values related to the cleaning effectiveness were compared. The Dockage Efficiency is a measure of how well the precleaner placed the dockage in the removed material stream. A Dockage Efficiency of 100% would indicate that all of the dockage was removed from the unclean grain and put into the removed material stream. The Clean Grain Efficiency is a measure of how well the precleaner placed the clean grain in the clean grain stream. A Clean Grain Efficiency of 100% would indicate that all of the clean grain was in the clean grain stream. Equations for the above two values are given in **Appendix II**.

For all three precleaners, the maximum capacity, Dockage Efficiency, and Clean Grain Efficiency were compared at different machine operating angles. The effect of grain flowrate on cleaning effectiveness was also determined.

It should be noted that these results are based on one run per setting using the machines obtained for this project. Experimental error and grain inconsistency may affect the accuracy of the results. Operation of other machines in different conditions may show different results.

2.5.1 Kwik Kleen Test Results

Wheat: The maximum flowrates of the Kwik Kleen in wheat are given in **Table 1**.

Table 1. Kwik Kleen Flowrates in Wheat.

Operating Position (In.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
6	115.6	4317
9	104.8	3913
12	107.8	4023

Based on the data above, it appears that maximum flowrate in wheat is not affected by operating angle. The effect on grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 2**.

Table 2. Kwik Kleen Cleaning Effectiveness in Wheat.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
6	31.6	23.2	99.1	99.2
9	12.5	32.2	101.4	99.3
12	36.0	44.4	98.2	44.4

Based on the data above, it appears that cleaning effectiveness is not affected by operating angle or flowrate. For all operating conditions, the Clean Grain Efficiency was 99% or higher. It appears that the Kwik Kleen does a good job of putting clean grain in the clean grain stream, but also puts clean grain in the removed material stream. It also appears that any adjustments do not have a consistent affect on the flowrate or cleaning effectiveness of this precleaner.

Canola: There is no test data for the Kwik Kleen in canola, because it was not able to consistently operate without the screens plugging. Two different manufacturer recommended screens were used, and both plugged after operating for only a few minutes. Based on these tests, it appears that the Kwik Kleen in not suitable for cleaning canola unless suitable screens can be found.

Peas: The maximum flowrates of the Kwik Kleen in peas are given in **Table 3**.

Table 3. Kwik Kleen Flowrates in Peas.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
6	101.0	3769
9	94.9	3542
12	81.6	3048

Based on the data above, it appears that maximum flowrate in peas increases as the operating angle decreases. The effect of grain flowrate on Dockage Efficiency and Clean Grain Efficiency is given in **Table 4**.

Table 4. Kwik Kleen Cleaning Effectiveness in Peas.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
6	160.0	71.7	89.7	96.9
9	92.0	104.7	96.0	93.4
12	44.6	76.0	101.7	96.1

Based on the data above, it appears that cleaning effectiveness is not affected by flowrate, but gets better as the operating angle is increased. For all operating conditions, the Clean Grain Efficiency was 89% or higher. It appears that the Kwik Kleen does a fairly good job of putting only dockage in the removed material stream and that operating this machine in peas is a compromise between capacity and cleaning effectiveness.

2.5.2 Farm King Test Results

Wheat: The maximum flowrates of the Farm King in wheat are given in **Table 5**.

Table 5. Farm King Flowrates in Wheat.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
1	26.5	991
2	27.1	1010
3	30.6	1141
4	24.9	928

Based on the data above, it appears that maximum flowrate in wheat is not affected by operating angle. The effect on grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 6**.

Table 6. Farm King Cleaning Effectiveness in Wheat.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
1	68.0	62.3	98.5	98.7
2	75.7	118.9	98.4	97.7
3	63.2	77.0	98.8	98.6
4	55.7	94.7	98.1	96.5

Based on the data above, it appears that cleaning effectiveness is not affected by operating angle but decreasing the flowrate results in increased cleaning effectiveness. For all operating conditions, the Clean Grain Efficiency was 96% or higher. It appears that the Farm King does a good job of putting clean grain in the clean grain stream, but also puts clean grain in the removed material stream. It also appears that operating this precleaner in wheat is a compromise between flowrate and cleaning effectiveness.

Canola: The maximum flowrates of the Farm King in canola are given in **Table 7**.

Table 7. Farm King Flowrates in Canola.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
Level	33.3	1244
1	24.4	910
2	21.3	799
3	31.7	1184

Based on the data above, it appears that maximum flowrate in canola increases with an increase in operating angle. The exception to this is that the maximum flowrate with the machine level was higher than at other operating angles. The effect on grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 8**.

Table 8. Farm King Cleaning Effectiveness in Canola.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
1	15.2	16.8	99.8	99.4
2	31.2	29.0	99.5	99.5
3	68.3	67.6	98.2	98.3
4	57.1	44.7	96.4	97.1

Based on the data above, it appears that the cleaning effectiveness is at a maximum at position 3 and not affected by flowrate. It was noted that with the machine level, the flowrate was high, but there was a large amount of clean grain in the material removed stream. For all operating conditions, the Clean Grain Efficiency was 96% or higher. It appears that there is an optimum operating angle to maximize the cleaning effectiveness of the Farm King in canola, and at this angle, the cleaning effectiveness is not affected by grain flowrate.

Peas: The maximum flowrates of the Farm King in peas are given in **Table 9**.

Table 9. Farm King Flowrates in Peas.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
Level	19.2	715
1	38.0	1418
2	30.8	1151
3	26.4	986
4	26.9	1005

Based on the data above, it appears that there is no consistent relationship between the maximum flowrate in peas and the operating angle. The effect of grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 10**.

Table 10. Farm King Cleaning Effectiveness in Peas.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
Level	108.5		82.7	
1	44.8	91.0	98.3	86.5
2	114.0	70.0	84.1	87.9
3	104.9	107.0	89.5	88.6
4	85.2	79.4	92.2	92.3

Based on the data above, it appears that the cleaning effectiveness is not affected by operating position, and is slightly improved with a reduction in grain flowrate. For all operating conditions, the Clean Grain Efficiency was between 84% and 92%. For the Farm King operating in peas, these tests showed that no adjustments, except grain flowrate to a small degree, affected the overall performance of this precleaner.

2.5.3 Bench Test Results

Wheat: The maximum flowrates of the Bench in wheat are given in **Table 11**.

Table 11. Bench Flowrates in Wheat.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
Level	12.4	462
4	15.2	567
8	14.0	522

Based on the data above, it appears that maximum flowrate in wheat is attained at the 4" operating position. The effect on grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 12**.

Table 12. Bench Cleaning Effectiveness in Wheat.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
Level	71.7	58.1	92.5	91.6
4	37.6	43.9	95.0	91.6
8	38.1	80.1	95.7	88.6

Based on the data above, it appears that at the 4 in. operating position, cleaning effectiveness is improved by reducing the flowrate. At other operating positions, reducing the flowrate either consistently decreased cleaning effectiveness or had an inconsistent effect. For all operating conditions, the Clean Grain Efficiency was 88% or higher. It appears that when using the Bench to clean wheat, the 4 in. operating position is the optimum setting, and that there is a compromise between flowrate and cleaning effectiveness.

Canola: The maximum flowrates of the Bench in canola are given in **Table 13**.

Table 13. Bench Flowrates in Canola.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
Level	17.5	654
4	8.4	314
8	15.9	595

Based on the data above, it appears that the 4 in. operating position results in a much lower flowrate than other positions. The effect on grain flowrate of Dockage Efficiency and Grain Cleaning Efficiency is given in **Table 14**.

Table 14. Bench Cleaning Effectiveness in Canola.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
Level	38.9	39.4	96.8	94.9
4	43.5	79.6	96.7	91.6
8	40.7	47.0	99.1	97.2

Based on the data above, it appears that reducing the flowrate increases the cleaning effectiveness in most cases, and that the level position may be the optimum. For all operating conditions, the Clean Grain Efficiency was 92% or higher. It appears that when using the Bench to clean canola, the level operating position is the optimum setting, and that there is a compromise between flowrate and cleaning effectiveness

Peas: The maximum flowrates of the Bench in peas are given in **Table 15**.

Table 15. Bench Flowrates in Peas.

Operating Position (in.)	Maximum Flowrate (t/h)	Maximum Flowrate (lb/min)
Level	16.8	627
4	10.0	375
8	17.9	667

Based on the data above, it appears that there is no consistent relationship between the maximum flowrate in peas and the operating angle. The effect on grain flowrate of Dockage Efficiency and Clean Grain Efficiency is given in **Table 16**.

Table 16. Bench Cleaning Effectiveness in Peas.

Operating Position (in.)	Dockage Efficiency (%)		Clean Grain Efficiency (%)	
	Maximum Flow	Reduced Flow	Maximum Flow	Reduced Flow
Level	64.1	101.7	102.0	96.5
4	84.3	N/A	98.6	N/A
8	95.8	71.0	96.5	103.1

Based on the data above, it appears that the cleaning effectiveness is not affected by operating position, and is slightly improved with a reduction in grain flowrate. For all operating conditions, the Clean Grain Efficiency was 96% or higher. For the Bench operating in peas, these tests showed in some cases a lower flowrate increased the cleaning effectiveness, and that operating position did not affect the overall performance of this precleaner.

2.6 Economic Analysis

2.6.1 Economic Model Development

The economic analysis portion of this project involved comparing the net return to the producer with no cleaning versus using a precleaner. For this analysis, no specific model of precleaner was investigated, but typical values from the testing were used as inputs into the economic model. The two scenarios investigated were using the precleaners to remove dockage, therefore reducing freight costs, and using the precleaners to improve the grade of the grain, therefore increasing the value of the grain. Below are descriptions of how each component of the economic model was developed.

To calculate the return to the producer if no cleaning was done, the first consideration was the grain price. This was obtained from organizations such as the Canadian Wheat Board and other grain purchasers. This value was the price paid to the producer before any freight or handling charges. From this, a freight cost was deducted. This is the cost to move the grain from the elevator to an export shipping point, and is dependent on the shipping distance. An elevating charge was also deducted, which represents the cost for the elevator to handle the grain. Freight plus elevating charges could be from $33 to $58/tonne, depending on the grain type and elevator location. The remainder was the price per tonne of grain paid to the producer. The actual quantity of grain used in calculating the total paid to the producer is the total mass delivered minus the dockage. Another cost to the producer is the transportation cost to get the grain from his farm to the elevator. For this project, local custom rates that were based on hauling distance and grain mass were used.

To calculate the net return when using a precleaner for dockage removal, the cleaning cost was first calculated. Some of the values used were based on the test results. These included 5% of the grain mass removed by the precleaner, and that the dockage level in the cleaned grain is 40% of the original. Therefore, after cleaning, 95% of the original mass would be hauled to the elevator and this grain would include 40% of the original dockage amount. The value of the dockages is based on the density, and could vary from $10 to $80/tonne. For this project, $50/tonne was used as a typical value.

The fixed cleaning costs included: depreciation, investment, repair, insurance, and housing costs. These were calculated using equations in the Farm Machinery Custom and Rental Rate Guide 1998 published by Saskatchewan Agriculture and Food. For this project, a salvage value of 10% was used, along with 100 hr/yr use, 10 year lifetime, 6.5% interest rate, $10/h labour rate, and electrical power requirements and grain

flowrates that were typical of the machines tested in this project. The net return to the producer was the total revenue (after freight, dockage, and elevating charges) minus transportation and cleaning costs, plus dockage revenue. This net return was compared to the net return if no cleaning was done.

An example of using the precleaners for grade improvement would be sizing barley so a portion of the total could be sold as malt barley with the remaining being sold as feed. In this case, the baseline scenario is all of the grain being at a lower price. After precleaning some grain will be at a higher price, and the remainder will stay at the lower price. All prices in this section are net after dockage. Freight, handling, cleaning, and trucking costs were deducted from the appropriate revenue, and the return from precleaning was the difference between the net return for both scenarios.

2.6.2 Economic Model Results

Typical values for a comparison baseline are given in **Table 17.**

Table 17. Baseline Values.

Grain Cleaned Per Year	450 tonnes
Wheat Price (before deduction)	$207/tonne
Freight and Handling Charge	$50/tonne
Dockage Amount	2%
Grain Removed by Precleaner	5%
Dockage Price	$50/tonne
Precleaner Capacity	20 tonne/h
Precleaner Power Requirements	5 hp
Precleaner Purchase Cost	$8,800.00

Using the above values the net return from precleaning was (-$1,910.28). Because this value is negative, it is not economically feasible to use precleaners to remove dockage under these conditions.

Several variables were changed to try to find a scenario where the precleaners would result in an economic advantage. Changing the hauling distance from 0 to 200 miles did not result in a positive return. Even with the dockage value at $80/tonne, the return is not positive. More dockage results in a higher return, but the dockage level had to be 7% or higher to result in a positive return. This is not common. Having more grain cleaned only made the return more negative. Raising the freight and handling charge made the return higher, but it had to reach $165/tonne before the return was positive. Raising the price of the grain made the return more negative.

Most of the above scenarios did not result in a net positive return because the precleaners are not perfect, and some otherwise good grain gets removed from the original mass and is sold at a much lower price as dockage. The gains from lower transportation, freight and handling costs do not offset this. Even if the precleaners removed only the dockage, the reduced trucking costs and dockage revenue do not offset the cleaning costs. Based on this analysis, it appears that in most circumstances, these precleaners will not result in a net positive economic return when used to only reduce dockage.

Regarding using the precleaners to improve grain grade, the scenario used as a baseline is barley that is 70% "plump". This barley would not grade malting, but if it was 85% plump, it would. Therefore, if the precleaners remove twice as much material as necessary then (85-70) x 2 = 30% of the original material would be removed. Typical values for a comparison baseline are given in **Table 18**.

Table 18. Baseline Value with Hauling Distances and Freight Costs.

Mass removed by precleaner	30% of original
Original grain mass	450 tonne
Original grain price	$132/tonne
Upgraded grain price	$185/tonne

The same as previous examples, the net return using the above values is $16,171. This is very encouraging. If the amount of material removed is as high as 95%, the net return is still positive, using the baseline prices. A price increase of as little as $11/tonne is needed for a net positive return at 30% material removal. Because cleaning costs are small compared to other costs in this situation, the capacity could be halved and the purchase price doubled, and the net return would still be $14,900. It is clear that using precleaners to improve grain grade can be a significant economic benefit to Saskatchewan producers.

4. Equipment

No equipment was purchased for this project.

5. Project Developed Materials

PAMI will be preparing a Research Update for this project in the near future. This will be sent to all PAMI subscribers and available on the Internet.

6. Project Photos

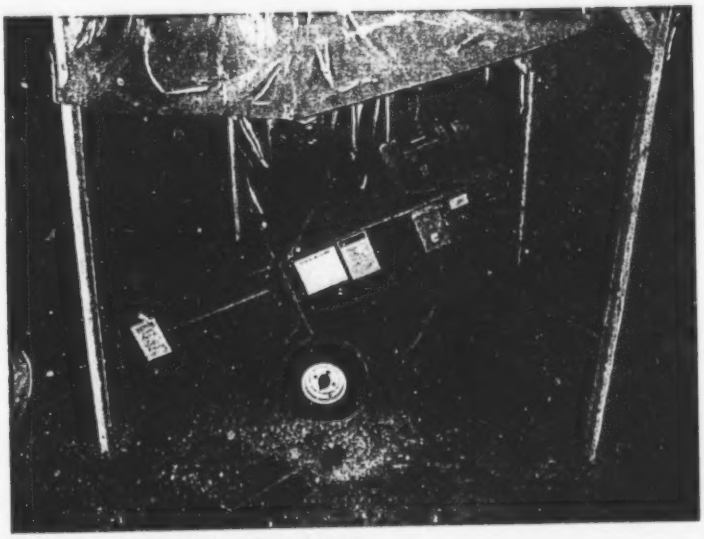

Figure 4. Kwik Kleen Test Set-up.

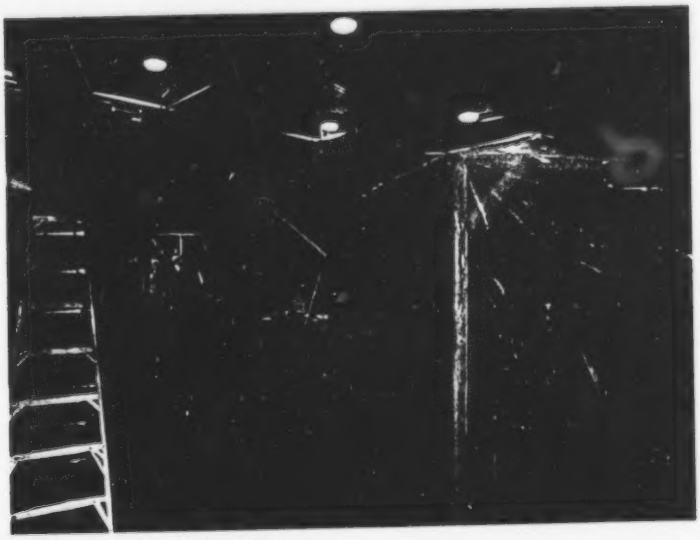

Figure 5. Bench Test Set-up.

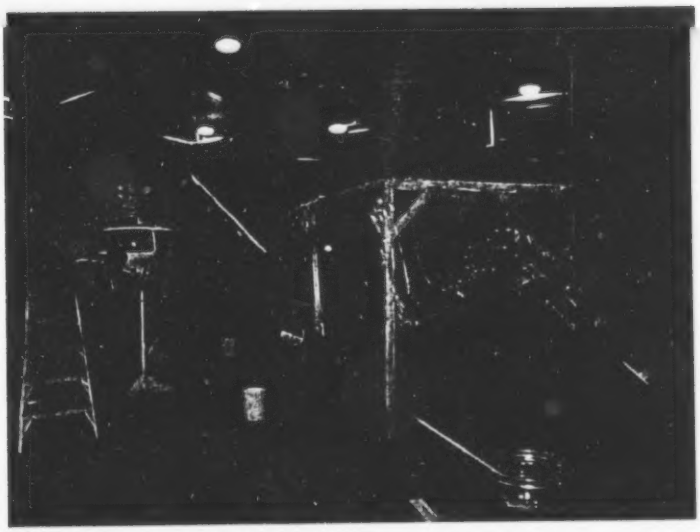

Figure 6. Farm King Test Set-up.

7. Acknowledgements

PAMI wishes to acknowledge the funding support provided by the Agriculture Development Fund of Saskatchewan Agriculture and Food.

APPENDIX I

Appendix I

Test Data Results

	Kwik Klean Results Summary																				
Wheat						bold numbers are average approximations															
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain							
		Flowrate	Removed	% fines	% coarses	% dockage	% fines	% coarses	% dockage	% fines	% coarses	% dockage	efficiency	efficiency							
		lb/min.											%	%							
3	9" RECOMMENDED HEIGHT, HALF FLOW	1355.574	0.70	1.01%	0.98%	1.99%	0.07%	0.92%	0.99%	31.92%	2.84%	34.76%	12.20	100.31							
4	9" RECOMMENDED HEIGHT, HALF FLOW	781.824	2.85	0.68%	2.56%	3.23%	0.14%	0.97%	1.10%	34.88%	1.71%	36.60%	32.26	99.29							
5	9" RECOMMENDED HEIGHT, MAX FLOW	3913.554	1.15	0.72%	2.88%	3.60%	0.22%	0.85%	1.07%	33.46%	5.88%	39.34%	12.55	101.44							
8	6" HEIGHT, MAX FLOW	4316.604	1.23	0.34%	1.36%	1.70%	0.37%	1.02%	1.39%	38.08%	5.62%	43.69%	31.64	99.09							
9	6" HEIGHT, HALF FLOW	2153.292	1.65			2.56%	0.52%	1.12%	1.65%	29.24%	5.95%	35.19%	23.21	99.21							
14	12" HEIGHT, MAX FLOW	4023.27	1.50	0.63%	1.33%	1.96%	0.51%	1.74%	2.24%	42.09%	5.02%	47.12%	35.97	98.22							
15	12" HEIGHT, HALF FLOW	1032.39	2.77			2.56%	0.13%	0.77%	0.90%	35.51%	4.53%	40.03%	44.39	98.83							
Canola																					
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain							
		Flowrate	Removed	% fines	% coarses	% dockage	% fines	% coarses	% dockage	% fines	% coarses	% dockage	efficiency	efficiency							
		lb/min.											%	%							
3	9" RECOMMENDED HEIGHT, HIGH FLOW	3283.052	3.36	2.80%	2.16%	4.96%	1.88%	3.05%	4.93%	13.93%	0.15%	14.07%	9.55	96.66							
4	9" RECOMMENDED HEIGHT, HALF FLOW	1542.918	0.32	2.12%	7.20%	9.32%	2.74%	4.82%	7.56%	79.67%	1.22%	80.89%	2.75	101.62							
7	12" POSITION, SLOW RUN	1453.812	0.15	2.94%	3.50%	6.45%	3.45%	3.53%	6.98%	87.13%	0.94%	88.08%	1.98	99.29							
Peas																					
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain							
		Flowrate	Removed	% fines	% splits	% dockage	% fines	% splits	% dockage	% fines	% splits	% dockage	efficiency	efficiency							
		lb/min.											%	%							
1	12" HEIGHT, HALF FLOW	1995.66	8.67	1.59%	9.79%	11.38%	0.32%	6.46%	6.78%	17.65%	82.17%	99.82%	76.03	96.08							
2	12" HEIGHT, SLOW FLOW	638.982	9.63	0.96%	9.76%	10.72%	0.10%	5.40%	5.49%	6.86%	92.99%	99.85%	89.69	95.66							
3	9" RECOMMENDED, HALF FLOW	1917.432	8.55	1.25%	6.89%	8.14%	0.15%	6.01%	6.15%	8.01%	91.78%	99.79%	104.74	93.43							
6	6" HEIGHT, HALF FLOW	1799.382	5.18	1.18%	6.03%	7.21%	0.20%	5.00%	5.20%	18.50%	81.22%	99.72%	71.70	96.87							
9	6" HEIGHT, MAX FLOW (BLEW BREAKER)	4286.312	3.20	1.10%	10.14%	11.24%	0.70%	5.12%	5.82%	13.02%	86.79%	99.81%	28.42	102.72							
10	9" RECOMMENDED, MAX FLOW	1900.614	4.89	0.75%	4.56%	5.31%	0.30%	4.15%	4.45%	11.99%	87.94%	99.93%	92.03	95.97							
11	9" RECOMMENDED, HIGH FLOW	2796.63	3.66	0.89%	3.46%	4.34%	0.41%	3.89%	4.30%	16.16%	83.63%	99.79%	84.07	96.38							
14	12" HEIGHT, MAX FLOW	3048.18	6.66	3.16%	11.68%	14.84%	0.55%	6.65%	7.19%	28.56%	70.83%	99.39%	44.61	101.72							
15	9" RECOMMENDED, MAX FLOW	3542.448	6.46	2.07%	8.92%	10.98%	0.73%	5.01%	5.73%	26.23%	73.50%	99.74%	58.70	99.05							
16	6" HEIGHT, MAX FLOW	3789.266	5.99	0.56%	3.16%	3.74%	0.63%	7.57%	8.20%	23.94%	75.89%	99.83%	150.97	89.65							

Farm King Results Summary

Wheat — bold numbers are average approximations

Run No.	Desc.	Grain Flowrate lb/min.	% Removed	Unclean Grain % fines	Unclean Grain % coarses	Unclean Grain % dockage	Clean Grain % fines	Clean Grain % coarses	Clean Grain % dockage	Fines % fines	Fines % coarses	Fines % dockage	Coarses % fines	Coarses % coarses	Coarses % dockage	Material Removed % fines	Material Removed % coarses	Material Removed % dockage	Dockage efficiency %	Clean Grain efficiency %
3	POSITION #4, MAX FLOW	928.062	2.42	0.46%	1.31%	1.77%	0.34%	0.88%	1.22%	45.43%	5.59%	51.03%	-0.64%	30.80%	30.16%	22.39%	18.20%	40.59%	55.65	98.12
4	POSITION #4, HALF FLOW	321.072	3.16	0.47%	0.92%	1.39%	0.64%	1.06%	1.69%	34.02%	8.46%	42.48%	-1.58%	42.41%	40.83%	16.23%	25.43%	41.66%	94.73	96.54
9	POSITION #3, MAX FLOW	1140.798	2.31			1.65%	0.32%	0.24%	0.57%	49.17%	4.21%	53.38%	0.29%	36.49%	36.79%	24.72%	20.36%	45.08%	63.17	98.76
10	POSITION #3, HALF FLOW	654.108	2.25			1.65%	0.27%	0.53%	0.80%	45.38%	8.10%	53.48%	0.27%	58.86%	59.13%	22.83%	33.46%	56.30%	77.00	98.59
11	POSITION #2, MAX FLOW	1009.722	2.17	0.00%	0.00%	1.65%	0.69%	0.40%	1.09%	53.84%	3.51%	57.36%	0.39%	57.10%	57.49%	27.12%	30.30%	57.43%	75.69	98.39
12	POSITION #2, HALF FLOW	572.574	2.75	0.63%	0.88%	1.52%	0.24%	0.82%	1.06%	46.77%	5.56%	52.32%	0.81%	77.80%	78.60%	23.80%	41.65%	65.45%	118.92	97.69
13	POSITION #1, MAX FLOW	991.332	2.30	0.00%	0.00%	1.65%	0.45%	0.36%	0.81%	40.70%	3.20%	43.90%	0.35%	53.48%	53.83%	20.53%	28.33%	48.86%	68.02	98.54
14	POSITION #1, HALF FLOW	486.468	2.57	0.87%	1.06%	1.92%	0.15%	0.51%	0.66%	36.85%	3.37%	40.22%	0.72%	52.26%	52.98%	18.78%	27.83%	46.60%	62.32	98.68

Canola

Run No.	Desc.	Grain Flowrate lb/min.	% Removed	Unclean Grain % fines	Unclean Grain % coarses	Unclean Grain % dockage	Clean Grain % fines	Clean Grain % coarses	Clean Grain % dockage	Material Removed % fines	Material Removed % coarses	Material Removed % dockage	Dockage efficiency %	Clean Grain efficiency %
1	POSITION #1, MAX FLOW	909.954	2.33	3.10%	1.80%	4.90%	2.51%	0.61%	3.12%	0.43%	65.19%	65.61%	31.18	99.50
2	POSITION #1, HALF FLOW	374.442	2.00	2.16%	2.65%	4.81%	2.23%	1.12%	3.35%	0.13%	69.48%	69.61%	28.97	99.50
5	POSITION #2, MAX FLOW	798.84	3.03	2.30%	2.12%	4.42%	2.13%	1.03%	3.16%	0.02%	99.48%	99.50%	68.32	98.24
6	POSITION #2, HALF FLOW	394.914	2.99	2.50%	1.90%	4.40%	2.12%	1.01%	3.13%	0.02%	99.41%	99.43%	67.58	98.30
9	POSITION #3, HALF FLOW	423.486	4.20	1.84%	2.76%	4.63%	2.35%	0.99%	3.34%	0.19%	48.85%	49.04%	44.47	97.10
10	POSITION #3, MAX FLOW	1184.388	5.25	2.73%	2.14%	4.86%	2.13%	1.09%	3.22%	0.15%	52.85%	53.00%	57.20	96.39
13	LEVEL POSITION, MAX FLOW	1244.418	3.07	3.41%	3.60%	7.01%	3.06%	1.19%	4.28%	0.20%	34.60%	34.80%	15.23	99.78
14	LEVEL POSITION, HALF FLOW	700.734	3.30	3.01%	3.99%	7.00%	3.29%	1.13%	4.42%	0.26%	35.47%	35.73%	16.82	99.39

Peas

Run No.	Desc.	Grain Flowrate lb/min.	% Removed	Unclean Grain % fines	Unclean Grain % splits	Unclean Grain % dockage	Clean Grain % fines	Clean Grain % splits	Clean Grain % dockage	Material Removed % fines	Material Removed % splits	Material Removed % dockage	Dockage efficiency %	Clean Grain efficiency %
3	LEVEL POSITION, MAX FLOW	714.726	23.62	0.62%	12.05%	12.67%	0.18%	5.30%	5.48%	8.70%	49.50%	58.20%	108.53	82.67
6	POSITION #1, MAX FLOW	1418.406	19.70	7.54%	19.22%	26.76%	0.86%	9.47%	10.33%	11.93%	48.97%	60.90%	44.83	98.32
7	POSITION #1, HALF FLOW	580.044	27.52	3.33%	16.37%	19.70%	0.28%	3.95%	4.23%	19.07%	46.05%	65.12%	90.95	86.45
8	POSITION #2, HALF FLOW	729.546	19.32	1.95%	10.49%	12.44%	0.33%	4.26%	4.59%	8.66%	38.41%	45.07%	70.03	87.90
11	POSITION #2, HIGH FLOW	1151.694	21.08	1.55%	9.85%	11.40%	0.54%	5.08%	5.62%	10.65%	51.19%	61.84%	114.40	84.07
12	POSITION #2, FLOOD FED	1853.328	10.09	0.36%	3.56%	3.95%	0.16%	5.13%	5.29%	7.93%	40.36%	48.29%	123.45	88.65
13	POSTION #3, HIGH FLOW	986.106	16.64	0.83%	9.02%	9.85%	0.11%	4.11%	4.22%	7.46%	55.92%	63.38%	107.04	88.57
14	POSITION #3, HALF FLOW	682.188	15.51	1.18%	8.16%	9.35%	0.02%	3.97%	4.00%	7.03%	56.16%	63.19%	104.88	89.47
17	POSITION #4, HIGH FLOW	1004.568	13.68	0.99%	9.53%	10.52%	0.17%	4.30%	4.47%	10.55%	54.98%	65.53%	85.20	92.16
18	POSITION #4, FLOOD FED	1568.466	14.17	1.34%	10.81%	12.15%	0.55%	6.20%	6.75%	10.90%	50.97%	61.87%	72.15	91.11
19	POSITION #4, HALF FLOW	681.844	13.80	1.09%	9.74%	10.83%	0.22%	4.32%	4.54%	7.97%	54.33%	62.30%	79.38	92.28

Bench Results Summary

bold numbers are average approximations

Wheat														
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain
		Flowrate	Removed	% fines	% coarses	% dockage	% fines	% coarses	% dockage	% fines	% coarses	% dockage	efficiency	efficiency
		lb/min.											%	%
3	MACHINE LEVEL, MAX TOP SCREEN FLOW	462.408	8.46			1.67%	0.19%	0.46%	0.66%	5.44%	8.65%	14.10%	71.65	92.48
4	MACHINE LEVEL, REDUCED FLOW RATE	358.698	9.52	1.11%	0.70%	1.80%	0.28%	0.25%	0.54%	8.84%	2.15%	10.99%	58.08	91.64
5	4" ELEVATION, MAX TOP SCREEN FLOW	567.084	5.89	1.53%	0.45%	1.98%	0.78%	0.25%	1.02%	7.69%	4.95%	12.65%	37.62	95.03
6	4" ELEVATION, REDUCED FLOW RATE	372.702	9.27			1.67%	0.06%	0.71%	0.77%	5.43%	2.46%	7.88%	43.89	91.56
7	6" ELEVATION, MAX TOP SCREEN FLOW	522.096	5.53	0.44%	1.13%	1.57%	0.12%	0.21%	0.33%	5.67%	5.13%	10.80%	38.08	95.66
8	6" ELEVATION, REDUCED FLOW RATE	266.85	12.23	0.00%	0.00%	1.67%	0.04%	0.67%	0.71%	6.06%	4.84%	10.90%	80.08	88.62
9	6" ELEVATION, SHAKE POS #3, MAX FLOW	419.514	10.80	0.37%	0.94%	1.31%	0.02%	0.30%	0.32%	5.39%	3.62%	9.01%	74.27	90.10
10	6" ELEVATION, SHAKE POS #3, 1/2 FLOW	238.008	16.33	0.00%	0.00%	1.67%	0.02%	0.49%	0.51%	3.68%	4.75%	8.43%	82.67	84.65

Canola														
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain
		Flowrate	Removed	% fines	% coarses	% dockage	% fines	% coarses	% dockage	% fines	% coarses	% dockage	efficiency	efficiency
		lb/min.											%	%
3	MACHINE LEVEL, MAX TOP SCREEN FLOW	653.766	6.98	2.89%	3.72%	6.62%	2.21%	0.57%	2.78%	13.77%	23.11%	36.88%	38.88	96.84
1	MACHINE LEVEL, BOTTOM SCREEN LOADED	107.544	16.21	9.31%	4.09%	13.40%	0.72%	1.22%	1.94%	15.30%	17.26%	32.55%	39.40	94.87
2	4" ELEVATION, MAX TOP SCREEN FLOW	314.388	8.05	3.05%	4.27%	7.32%	1.73%	0.81%	2.53%	18.23%	21.37%	39.60%	43.51	96.71
3	4" ELEVATION, BOTTOM SCREEN LOADED	144.996	13.68	3.28%	4.23%	7.51%	0.86%	1.03%	1.89%	16.13%	27.54%	43.67%	79.61	91.56
4	6" ELEVATION, BOTTOM SCREEN LOADED	312.468	7.14	2.67%	4.51%	7.18%	1.94%	0.86%	2.81%	18.89%	28.37%	47.26%	46.96	97.24
5	6" ELEVATION, MAX TOP SCREEN FLOW	594.78	5.00	3.74%	3.42%	7.16%	2.46%	0.74%	3.20%	17.55%	40.77%	58.32%	40.68	99.06

Peas														
Run No.	Desc.	Grain	%	Unclean Grain			Clean Grain			Material Removed			Dockage	Clean Grain
		Flowrate	Removed	% fines	% splits	% dockage	% fines	% splits	% dockage	% fines	% splits	% dockage	efficiency	efficiency
		lb/min.											%	%
3	LEVEL, HALF FLOW	394.524	13.42	2.34%	10.16%	12.50%	0.38%	2.07%	2.46%	14.36%	80.34%	94.69%	101.67	98.52
4	LEVEL, MAX FLOW	627.108	11.36	3.45%	13.75%	17.21%	0.27%	4.49%	4.76%	21.40%	75.62%	97.01%	64.06	101.96
5	4" ELEVATION, MAX CAPACITY	375.066	17.40	4.10%	15.16%	19.26%	0.06%	3.57%	3.63%	18.62%	74.71%	93.33%	84.33	98.59
6	4" ELEVATION, OVERLOADED	716.472	9.06	1.62%	13.05%	14.67%	0.62%	6.44%	7.06%	23.93%	72.76%	96.68%	59.73	99.04
9	8" ELEVATION, MAX CAPACITY	667.302	11.67	0.98%	10.12%	11.10%	0.05%	2.88%	2.93%	16.95%	74.21%	91.16%	95.80	98.45
10	8" ELEVATION, HALF CAPACITY	645.594	10.19	1.11%	12.25%	13.37%	0.06%	0.49%	0.55%	10.78%	82.38%	93.16%	71.01	103.10

APPENDIX II

Appendix II

Data Analysis Equations

$$\text{Dockage Efficiency} = \frac{(\%Material\ \text{Re}\ moved)(\%DockageofMaterial\ \text{Re}\ moved)}{\%DockageofUncleanedGrain}$$

$$\text{Clean Grain Efficiency} = \frac{(1-\%DockageofCleanGrain)(1-\%Material\ \text{Re}\ moved)}{(1-\%DockageofUncleanedGrain)}$$

APPENDIX III

Appendix III

Machine Specifications

Kwik Kleen

Screen Dimensions	72 ½" long x 6" diameter
Auger Speed	500 rpm
Motor	7 ½ hp, 230 V
Wheat Screens	8/64" round hole
Canola Screens	5/64" round hole 2.5/64 x 34 slot
Pea Screens	9/64 x ¾ slot

Farm King

Outer Screen	98" long x 48" diameter
Inner Screen	60" long x 30 intake diameter & 24" exhaust dia.
Screen Speed	19 rpm
Motors	2 hp, 230 V on filling auger 3 hp, 230 V on screen
Wheat Screens	4 x 4 x 23 ga. Inner 8 x 8 x 27 ga. Outer
Canola Screens	4 x 4 x 23 ga. Inner 8 x 8 x 27 ga. Outer
Pea Screens	2 x 2 x 19 ga. Inner 4 x 4 x 23 ga. Outer

Bench

Screen Deck Area	51 ¾" x 107" each, upper & lower 3 screens per deck
Driven Shaft Speed	515 rpm
Stroke Length	3/8"
Motors	2 hp, 230 V on filling augers 1hp, 230 V on screen deck
Wheat Screens	#14 round hole upper #5 slot lower
Canola Screens	7/64" round hole (2 screens) + 6/64" round hole (1 screen) 3/64" slot lower deck
Pea Screens	#24 round hole upper #11 slot lower